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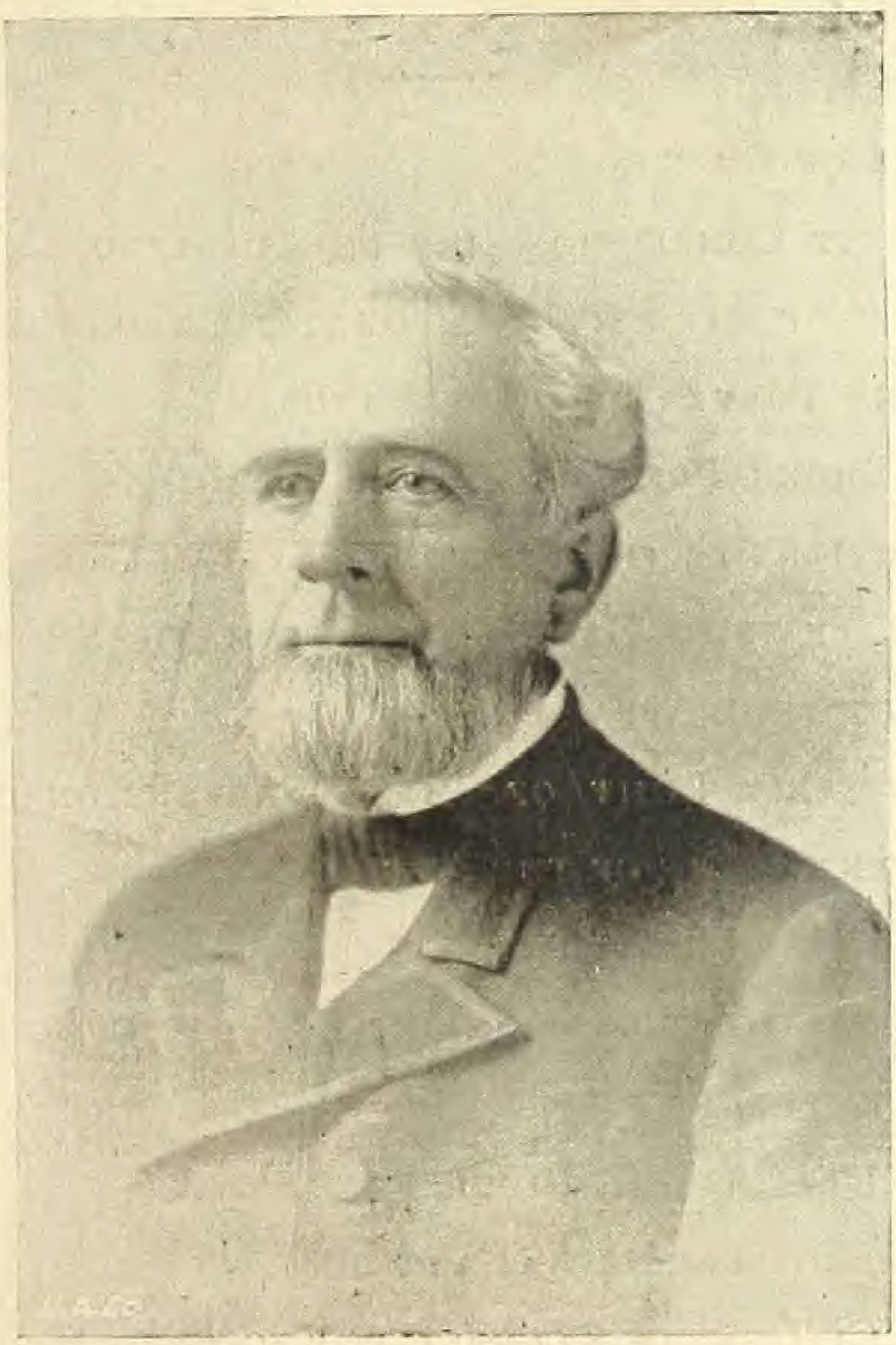
SOME FACTS OF INTEREST

IN REGARD TO

SARGENT'S AUTOMATIC SMOKE PREVENTER.



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Union and Advertiser Press, Rochester, N. Y.

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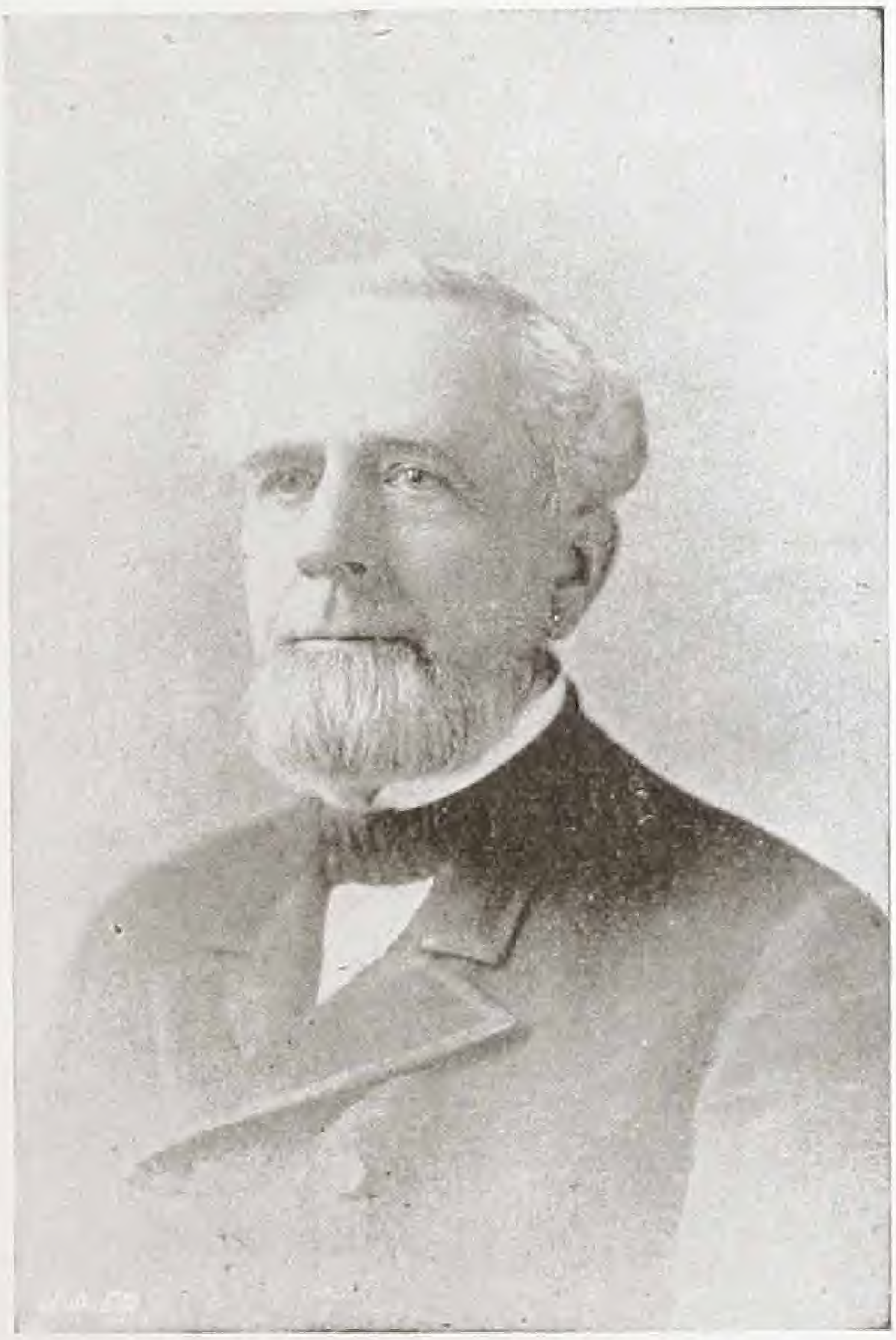
SARGENT'S

Patent Automatic Smoke Preventer.



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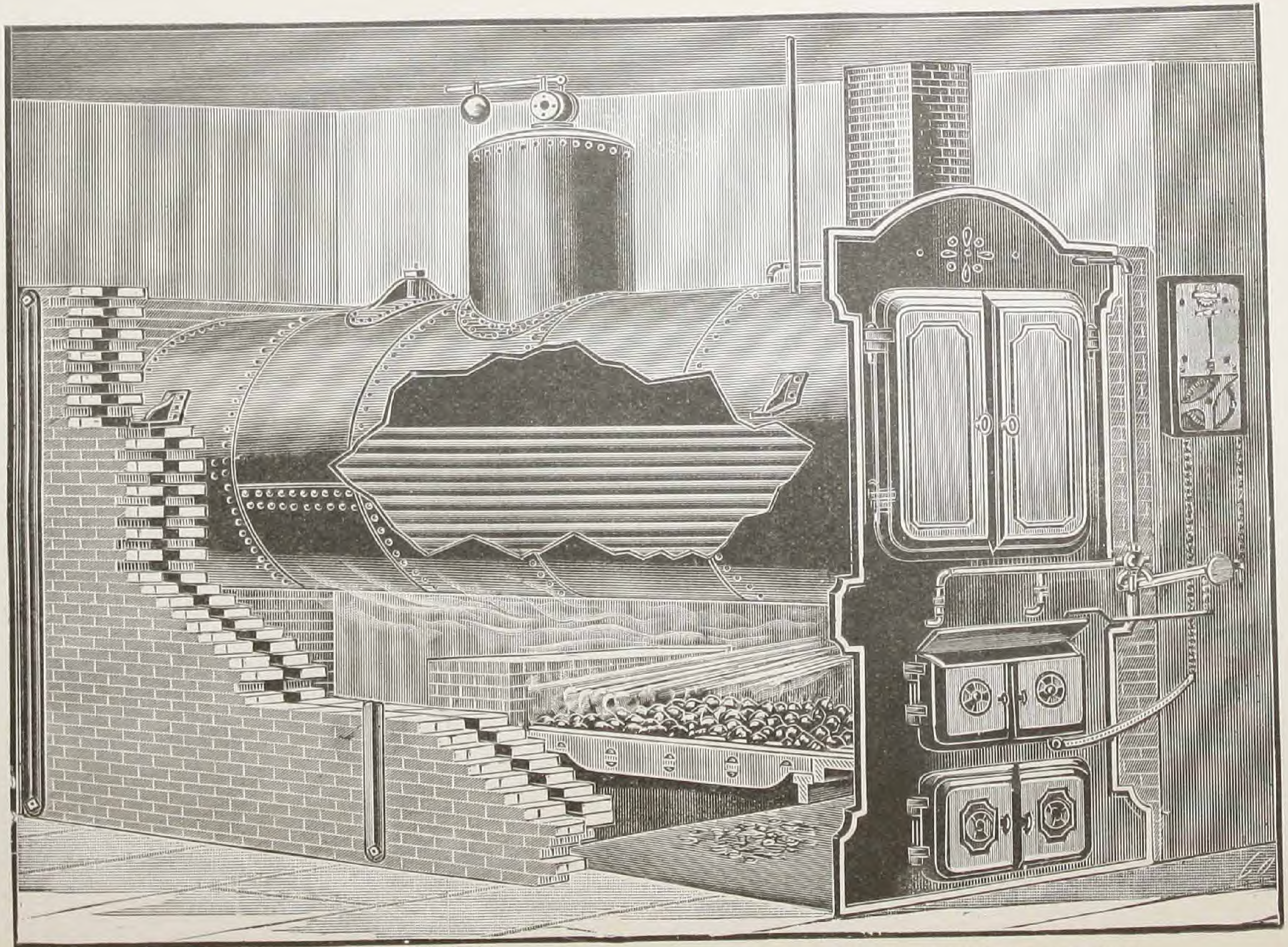

STEAM BOILER FURNACE FITTED WITH SARGENT'S AUTOMATIC SMOKE PREVENTER.

On the Proper Method of Burning Bituminous Coal in Order to Avoid the Production of Smoke.

THE CAUSE OF SMOKE.

In order to understand the cause of smoke it is necessary to first examine the phenomena of combustion. On doing this we find that coal is composed of two distinct parts, namely, the organic and the inorganic. The organic combustible part is a complex combination of carbon and hydrogen, with other elements; while the inorganic, incombustible part, constituting the ash, is composed mainly of essential ash and clay, mixed with a number of minor impurities. In the combustible part the more useful elements are the hydrogen and carbon, which under a sufficiently elevated temperature combine chemically with the oxygen of the air, with the result of producing sensible heat.

One necessary condition for complete combustion is an elevated temperature. Whenever an attempt is made to burn fuel at too low a temperature a process of distillation takes place by which certain volatile constituents of the combustible portion of the fuel are driven off and pass away through the chimney without being consumed. This is especially true in the case of burning bituminous coal at too low a temperature—the most marked product of the distillation being a dense, black smoke, composed largely of particles of carbon, and which escape from the furnace before reaching the temperature of incandescence. The minute particles of carbon so escaping possess very strong coloring properties, and are the chief cause of the serious discoloration of objects which is the usual accompaniment of the smoke nuisance. The actual quantity of the minutely sub-divided carbon, however, is small and by itself its loss cannot be considered a serious reduction of the heating capacity of a fuel.

Unfortunately the same low temperature of fire which leads to the production of black smoke is accompanied by an incomplete combustion of the other volatile constituents of the fuel—the result being the production of a considerable quantity of carbonic oxide instead of carbonic acid, which is the final outcome of complete combustion. Again, inasmuch as the carbonic oxide passes off with the smoke the same as though the fuel had been reduced to the state of complete oxidation as carbonic acid, the production of any large amount of it represents a very serious waste of heating capacity.

By way of saliently illustrating the difference between combustion to carbonic oxide and to carbonic acid we need only to remember (1) that the intensity of the heat of combustion is in proportion to the amount of oxygen consumed; and (2) that combustion to carbonic acid requires double the amount of oxygen that is required for combustion to carbonic oxide. Without going more elaborately into the theory of the matter we may say then that smoke, so far as the present discussion is concerned, is merely unconsumed fuel—and hence the problem of smoke prevention becomes purely a question of producing more perfect combustion.

In order to accomplish perfect combustion two conditions are essential:—

1. A temperature in the furnace of about 2000° F.

2. A plentiful supply of oxygen at all times, but especially during the period of distillation which succeeds the introduction of fresh fuel.

In regard to the first condition we may note that the temperature within the body of an ordinary fire is from 800° to 1000° F., or at a temperature about 1000° below what we may term *the temperature of complete combustion.*

If we consider the case of the ordinary steam boiler furnace we find an incandescent mass of fuel upon which fresh coal of the temperature of the air is often thrown, in relatively large quantities. The objectionable constituents of smoke are distilled from this fresh coal and pass into the chimney without having attained, even approximately, the temperature of complete combustion.

HOW PERFECT COMBUSTION MAY BE ATTAINED.

It has been known for a long time that the introduction into the furnace of a jet of dry steam is an efficient assistant to combustion, and when we join thereto such mechanical arrangements as further permit of automatic control not only of the steam jet but of a strong current of air so directed as to reach the point in the furnace where it will do the greatest amount of good, we may be said to have reached the practicable limit of improvement in this particular department of steam engineering.

The office of the steam jet is two-fold: In the first place it acts somewhat on the principle of the blowpipe, carrying into the furnace at the proper time and to the proper point a large volume of air. In the second place the dry steam is partially decomposed into its constituent elementary gases, oxygen and hydrogen. The burning of the liberated hydrogen of itself materially assists in intensifying the process of combustion, while the presence of a considerable portion of free oxygen further assists the same. The net result of the several complex reactions which thus take place is such an intensification of the whole combustive process as to easily raise the temperature of the gases in the furnace, above the incandescent coal, to the temperature of complete combustion. This leads again to incandescence of the distilled carbon and solid hydro-carbons with the final result of reducing nearly all the carbonaceous matter to the form of carbonic acid, which passes off through the chimney as an absolutely invisible, and, so far as the health, cleanliness and convenience of urban communities is concerned, as an absolutely harmless gas.

Under this head we may remark that the combustion of the hydrogen of fuel produces a considerable quantity of steam, which also passes off through the chimney the same as the other residual products of combustion. The effect of the steam so produced, as regards the smoke nuisance, is chiefly to dilute the unconsumed carbon, and at the same time, by becoming intimately mixed therewith, the steam is enabled to transport the fine particles to considerable distances. If smoke issued from chimney tops in a perfectly dry state, the unconsumed solid carbon would fall as a cloud of black dust, and in the case of large

furnaces would quickly cover all objects in the immediate vicinity with a thick coating of lampblack. So far as the smoke nuisance is concerned, the office of the steam, naturally present in smoke is therefore to assist in distributing the objectionable constituents throughout the upper atmosphere, rather than to allow them to settle upon a limited area, producing thereon an unbearable nuisance. That the amount of steam naturally contained in smoke is considerable will be readily appreciated when it is stated that the combustion of one ton of average bituminous coal produces from 600 to 700 pounds of steam.

From the foregoing facts we derive the conclusion that if by any process we can considerably reduce the particles of minutely divided carbon in smoke, and at the same time maintain the usual quantity of steam therein, we may expect to practically remove the smoke nuisance.

Let us see how this can be accomplished.

SARGENT'S AUTOMATIC CHRONOMETRIC SMOKE PREVENTING APPARATUS.

The city of Rochester, N. Y., in spite of being a great manufacturing center has long been widely known as perhaps the cleanest of the medium sized cities of the United States. Until recently the Genesee river furnished ample power for all purposes, and the soft coal smoke nuisance was unknown. In the last few years however, there has been so considerable an extension of the manufacturing interests of the city as to exhaust the present power producing capacity of the river, and soft coal has come rapidly into use with the result that the smoke nuisance has assumed serious proportions. This has happened so quickly that the change has been patent to every citizen, and probably the problem of smoke prevention has received as much intelligent consideration at Rochester as at any place in the country. A committee of the Chamber of Commerce of the city investigated the subject about two years ago, and as the result of broad study

was forced to the conclusion that all smoke consuming appliances thus far introduced into use in this country are somewhat uncertain in their operation—largely by reason of lacking efficient devices for quickly, easily and certainly controling their action at any and all stages of the fire. The possibility of developing a smoke preventing apparatus which should be absolutely automatic in its operation, presented itself to the mind of James Sargent, Esq., the well-known inventor of the time lock of this city. Experiments on a large scale were instituted, and now after nearly two years preliminary work, and the expenditure of several thousand dollars, Mr. Sargent is able to present the Automatic, Chronometric Smoke Preventing Apparatus as on the whole the most practicable solution of the problem of smoke consumption or prevention that has thus far been produced. The experiments have included the setting up and trial under conditions of actual use of a large number of smoke consuming appliances. Moreover while this experimental work has been in process, experts in the employ of Mr. Sargent have examined and reported upon nearly every similar device in use in the United States. The result of all this has been to force Mr. Sargent to the conclusion that automatic control of a steam jet in conjunction with the introduction at the proper time of an adequate volume of air is the true solution. The mechanism for accomplishing this has been worked out on lines entirely different from those hitherto followed. An ingenious application of the principle of the time lock has been made by which the act of opening the furnace door for the purpose of supplying fresh fuel, winds a clock train set to run down in a given period of time, opens an air inlet and also the valve controling the admission of steam. The running down of the clock shuts the air inlet, together with the steam valve. The length of time for the clock to run is determined by the average firing of the furnace, and may be made to vary in summer and winter and from day to day or whenever there is any considerable variation in the demand for steam with its consequent demand for heavier firing. The apparatus may be attached in a few hours to any steam setting, without in any way interfering with its regular and continuous use. It is durable, and when once in place requires no more attention than any other fitting to the boiler or furnace. It is moderate in first cost and its use in

the majority of cases will lead to an economy of fuel sufficient to pay for it in a short time.

The general features of the appliance may be gathered from the cut facing page 3, in which is exhibited a sectional elevation of a steam boiler and furnace with the apparatus attached and in full operation. Dry steam is conveyed from the top of the boiler and injected into the fire-box through properly arranged jets with a special form of tip. In the cut the number of tips is two, which may be considered the number, which in ordinary cases will give the best results although in one class of special cases a single jet will be sufficient, while in another, three or more will be used. The special tip is so constructed as to distribute a thin sheet of steam moving with high velocity throughout the entire upper portion of the fire-box. As shown in the cut the steam jets enter the fire-box *above* the air inlet, whence it results that the current of air is carried into the furnace in a solid column, which, for a considerable portion of its journey from the boiler front to the bridge wall is mostly confined between the sheet of steam above it, and the live fire beneath. The specific heat of air is so slight that the entering air current quickly reaches the temperature of the incandescent coal beneath, so that by the time the current reaches the vicinity of the bridge wall it is in proper condition to produce, in conjunction with the steam, a complete combustion in the manner described.

Moreover, during the latter part of the journey from front to rear in the fire-box, the expansion of the air currant has caused it to ascend and mingle with the steam jet, thereby producing, through the medium of a blow-pipe action, the necessary conditions for perfect combustion.

The production of an increased combustion with its consequent increase in quantity of heat energy, is proven in two ways, both of which are made evident on examination to any observer, and without the intervention of any elaborate scientific tests, viz.:

1. With uniform demand for steam upon the boilers the steam gage shows increased pressure while the smoke preventing appliance is in operation.

2. When bituminous coal is burned in the usual manner a black gummy soot attaches itself to the boiler tubes, and which it is found necessary to remove at least once each day as otherwise

the steam making capacity of the boiler is greatly reduced. With this appliance in regular operation, once a week is often enough to clean the tubes, and even then the only material removed is dry ashes which have been carried forward by the action of the draft. The heating surface of the boiler remains as bright as when first used.

This device is also valuable for increasing the draft, and experience has shown that furnaces which previously required a blower are successfully operated without one when this appliance is introduced. Incidental to this result the steam valve and jet are arranged with reference to delivering a small quantity of steam into the furnace after the clock train has ceased to operate.

Summarizing the whole matter it may be said that this invention possesses the merit of complete automatic control of all the essential conditions for successful combustion of bituminous coal. Its salient advantages are :—

1. The automatic control by means of the time movement of the steam jet, its action being such as to not only put the jet in active operation whenever fresh coal is added to the furnace, but to discontinue it as soon as the volatile constituents are driven off and the coal reduced to the state of coke.

2. The turning on and discontinuing in the same manner, and at the proper time, of the required amount of air current.

3. The producing of the net result of increased combustion, and greatly decreased smoke production.

4. Incidentally a considerable increase in the draft.

5. The producing of the foregoing results not only without any increase in the expense of operating, but in many cases, with material decrease.

ST. LOUIS SMOKE PREVENTION REPORT.

Something over a year ago the Engineers' Club of St. Louis appointed a committee to investigate the soft coal smoke problem and report to the club such recommendations as might tend to abate the serious smoke nuisance prevailing in that city.

The committee investigated all classes of smoke-consuming devices thus far used in the United States and give in their final

report, a general account of the same with such discussion as easily makes the report the most valuable contribution to the literature of smoke prevention which has thus far appeared. The suggestions are mostly up to date, and we may confidently refer to this report as, on the whole, an authoritative exposition of the fundamental principles underlying rational smoke prevention.

After defining the nature of the problem of smoke consumption the committee lay down the following ten requirements which any smoke-consuming or preventing device must satisfy in order to fully meet the varying conditions obtaining in ordinary practice, viz :—

1. It should develop such high temperature and oxidizing action as to insure the combustion of the free or separated carbon which forms the visible smoke.

2. It should insure regularity of action under the varying conditions induced by charging fresh coal, cleaning fires, inattention of firemen, etc.

3. It should not be susceptible to derangement under the conditions likely to obtain in use such as carelessness of firemen, inferior water, bad clinker, etc.

4. If there is any increase in the cost of operation it should be small.

5. The capacity of the apparatus should be such that efficient action will be secured not only when the boiler is working up to its full-rated capacity, but even when forced in order to meet extraordinary demands.

6. The apparatus should be readily adjustable to all forms of boilers and boiler settings.

7. It should be susceptible of application to boiler settings where the space is already limited.

8. It should be of comparatively low first cost.

9. Repairs should be small in amount, easily made and low of cost.

10. The apparatus should operate without injury to boiler or other accessories.

Mr. Sargent makes the broad claim that his Automatic Chronometric Smoke-Preventing Device fairly meets the requirements

of the ten conditions which the St. Louis committee have laid down.

The committee classify the various types of smoke-preventing devices which have thus far been proposed, as follows :—

1. Steam jets.
2. Firebrick arches or checker work.
3. Hollow walls for preheating air.
4. Coking arches or chambers.
5. Double-combustion furnaces.
6. Downward draught furnaces.
7. Automatic stokers.

In regard to steam jets the committee deem the conditions for successful operation to be chiefly :—

1. A suitable arrangement of the jets.
2. An intelligent management of the firing.
3. The providing of sufficient boiler capacity.

Assuming these requirements as met the committee say :— "Under such conditions the steam jet system can undoubtedly be made to yield satisfactory results in controlling the smoke."

The committee further discuss the relative advantages and disadvantages of the various other methods of smoke prevention as classified in the foregoing. The report is too voluminous for an extended abstract in this place, and we may simply say, that in substance it is pointed out, that all smoke consuming devices thus far tried at St. Louis are in some particular defective. Mr. Sargent claims, however, that the improvements in the jet system which are introduced in his Automatic Chronometric Apparatus are of such value as to render this system when fitted with his controlling appliances, the simplest and the best in use.

SOME OBJECTIONS TO THE STEAM JET SYSTEM CONSIDERED.

The steam jet system without automatic control has been in use in a number of different forms for several years, and in some cases

VIEW OF W. S. KIMBALL'S TOBACCO FACTORY, JUNE 23, 1892, WITHOUT THE SMOKE PREVENTER IN OPERATION.

for lack of proper application has failed to give satisfactory results. The most usual form of application has been to simply inject a continuous jet of steam into the fire box without reference to either a due supply of air or to the relation which subsists between the quantity of steam injected and the magnitude of the fire.

The St. Louis committee, after reciting the various objections to the steam jet system as ordinarily applied, remark :—"On the other hand it may be said that the requisite engineering skill and experience can always be obtained if sought for to secure a safe and suitable application of the system."

It may be further noted that the committee in making not only this, but the previously quoted strong indorsement of the general efficiency of the steam jet system, were referring to its use as ordinarily applied without automatic control, and subject to the vicissitude of constant attention on the part of the fireman. The notable improvements made by Mr. Sargent had not been brought to the attention of the committee previous to the making of their valuable report.

The objections outlined in the foregoing statement of objections are all fully met in Sargent's Automatic Appliance, as for instance:

1. The steam jet does not act in full force continuously, but is automatically increased in quantity whenever fresh fuel is added. In the same manner it is decreased as the volatile smoke producing constituents are gradually distilled off and consumed.

2. The amount of steam admitted is adapted to the quantity and quality of the fire.

3. The air inlet is automatically controlled in the same manner as the steam jet, with the quantity of air admitted adjusted to the quantity and quality of the fire.

The further objection has been made that this system adds to the expense of operation by reason of consuming a large amount of steam. The experiments which have been made and which may be found recorded on pages 15 to 18 disprove this proposition and prove that when properly applied there is a definite gain in economy of fuel, in addition to preventing the production of smoke.

VIEW OF W. S. KIMBALL'S TOBACCO FACTORY, JUNE 22, 1892, WITH THE SMOKE PREVENTER IN OPERATION.

EFFICIENCY TESTS OF SARGENT'S AUTOMATIC SMOKE PREVENTING APPARATUS.

The following tests of this apparatus were made at W. S. Kimball's Tobacco Factory in Rochester, N. Y., in June, 1892:

June 22—*With Smoke Preventer in Operation.*	June 23—*Without Smoke Preventer in Operation.*
2433 pounds of coal consumed in seven hours and twenty minutes.	2433 pounds of coal consumed in six hours and forty minutes.
Weight of water evaporated—21,600 pounds—8.88 pounds of water per pound of coal.	Weight of water evaporated—18,823 pounds—7.73 pounds of water per pound of coal.
Steam pressure 66 pounds.	Steam pressure 64 pounds.
Comparatively little smoke at any time.	At each firing and from five to eight minutes afterwards a heavy volume of smoke issued from the chimney.

W. J. DUNN,
Engineer.

From the foregoing report it appears that 2433 pounds of coal when burned with this apparatus in use supplied the fire 40 minutes longer than when the same quantity was burned without it. The report also shows that 2777 more pounds of water were evaporated with this amount of coal when the apparatus was in use, and at the same time the steam pressure maintained 2 pounds higher than when the apparatus was not in use.

The gain in water evaporated when the apparatus was in use, per pound of coal burned, was (8.88—7.33)=1.15 pounds.

These tests were made by W. S. Kimball & Co. without any request for the same on the part of Mr. Sargent and purely for the purpose of satisfying themselves as to the utility of the apparatus. The outcome, however, was so interesting that Mr. Sargent considered it desirable to make further efficiency-tests by way of verifying Messrs. Kimball & Co.'s results. A record of additional tests as made by George W. Rafter, a well-known engineer of Rochester, may be found in the following report :

ROCHESTER, N. Y., Oct. 10, 1892.

James Sargent, Esq.:

DEAR SIR—I herewith submit my report relative to tests of efficiency of the smoke preventing apparatus as made at Messrs. Sargent & Greenleaf's Lock Factory during Wednesday, Thursday and Friday of last week, (October 5, 6 and 7).

The following are the main elements to be taken into account in considering the results of these tests: The steam boiler in use is an ordinary horizontal tubular boiler 5 feet in diameter and 13 feet in length, with 76 flues each 3 inches internal diameter. The heating surface is about 1020 square feet, while the grate area is about 25 square feet, giving a ratio of grate surface to heating surface of nearly 41 to 1. The coal used was Reynoldsville "Run of the mine."

The height of chimney is about 60 feet with 4 square feet area of flue.

The feed water first passes through an Otis heater which receives the exhaust from the engine, after which it flows through pipes laid in the sides of the furnace before actually passing into the boiler at the flue line. The temperature of 192° as recorded in the table was taken after the feed water had passed through the heater and just before its delivery to the pipes in sides of furnace. This temperature therefore represents the actual temperature from which the water was heated by the fire.

Without going into further detail it may be stated that during the days of the test the factory was operated as certified by Major Streeter, the superintendent, in the ordinary manner. The firing and management of the boiler were also the same as usual, as certified by Mr. Middaugh, the engineer. All observations as to weight of water and coal, temperature of feed water, air, etc., were made by the undersigned.

During Wednesday, Oct. 5, when the smoke preventer was not in operation, large quantities of smoke issued from the chimney for from three to five minutes after each firing, while during Thursday and Friday, Oct. 6 and 7, with the appliance in operation, the smoke was reduced to a mere nothing—none appearing except for a few moments at the time of firing.

The difference in the labor of firing was also very noticeable. Without the smoke preventing apparatus the fire required consid-

erably more attention, in order to keep the boiler pressure up to 80 pounds than with. Indeed during the morning of Wednesday Oct. 5, it was found to be impossible to keep the steam pressure up without the assistance of a blower, the use of which has been discontinued since the steam jet was put in operation on this boiler. This was probably due to a large demand for steam for heating the building. In the afternoon, however, with less demand for steam the plant was operated without the blower, although the labor of attending to the fire was greater than on the following days when the steam jet was used. On Wednesday A. M. the demand for steam during the first two or three hours of the day was about the same as on Thursday, nevertheless, with the steam jet in use under automatic control, no difficulty at all was experienced in keeping steam pressure up to and even somewhat above 80 pounds.

The more important results of the tests are indicated in the following table:

Conditions.	Date.		
	Oct. 5.	Oct. 6.	Oct. 7.
	Smoke Preventing Appliance not Operated.	Smoke Preventing Appliance in Operation.	Smoke Preventing Appliance in Operation.
Number of pounds of coal burned in 10 hours	2572	2441	2316
Number of pounds of water evaporated in 10 hours	20430	22311	21312
Number of pounds of water evaporated per pound of coal consumed	7.94	9.14	9.20
Average boiler pressure (pounds)	79.3	82.4	83.5
Temperature of feed water	192°	192°	192°
Temperature of air in boiler room	80°	79°	81°

Referring to the table it appears that on Oct. 6, with the Smoke Preventer in use the amount of coal consumed was 131 pounds less than on the previous day; while on Oct. 7, the decrease in coal consumption was 256 pounds. The water evaporation was however greater on both days when the apparatus was used than when it was not. Taking the increase in evaporation per pound of coal consumed and we find that for the days when the apparatus

was in use the increase amounted to 1.20 pounds of water per pound of coal on Thursday, and 1.26 pounds on Friday.

The amount of steam actually passed into the furnace in order to produce the foregoing results amounted to about 600 pounds for the 10 hours' run, as determined by computation from formula for discharge of steam through jets of the known size and for the time actually in use. It may be of interest to note that, had the steam jet been allowed to run continuously, as is usually the case when such jets are operated for this purpose, without automatic control, the amount of steam discharged into the furnace would have been at least 2400 pounds for the 10 hour's run. Without going elaborately into this part of the subject it will be sufficient to remark that the difference of 1800 pounds of steam represents in this case the saving in use of steam by reason of automatic control.

Again, the use of the 600 pounds of steam in the manner indicated led to such intensification of the combustive process, as to not only prevent the formation of any objectionable smoke but further increased the net useful effect of the fuel over 10 per cent.

There seems to be no reason therefore why you are not justified in claiming for the steam jet system as used at the Lock Factory not only successful smoke prevention but some saving in fuel as well. Respectfully submitted,

GEO. W. RAFTER, M. Am. Soc. C. E.

ROCHESTER, N. Y., October 10, 1892.

I hereby certify that on the dates Oct. 5, 6 and 7, Sargent & Greenleaf's Lock Factory was operated in the usual manner both as to amount of power and use of steam for heating purposes.

WM. STREETER, Superintendent.

ROCHESTER, N. Y., Oct. 10, 1892.

I hereby certify that on the dates Oct. 5, 6 and 7, the firing of the steam boiler furnace at Sargent & Greenleaf's Lock Factory was done in the usual manner—no variation occurring on either day from my ordinary practice of firing.

L. S. MIDDAUGH, Engineer.

THE PRACTICABLE LIMIT OF SMOKE PREVENTION IN THE PRESENT STATE OF THE ART.

In putting the Automatic Smoke Preventer before the public it is considered desirable to define so far as possible the limits within which smoke prevention can be made practicably successful. This is especially important in view of the widely varying views which have prevailed among the different parties interested. On the one hand the general public have insisted that the emission of any quantity of smoke at all was a nuisance, to be immediately and forcibly abated by the vigorous enforcement of stringent municipal ordinance. On the other hand, the users of steam boilers have claimed, with perfect justice, that the entire prevention of smoke emission was impossible, and that the enforcement of ordinances demanding such a result was in effect an arbitrary prohibition of the use of soft coal,—a prohibition, further, which in many cases would render it either nearly or entirely impossible to continue important and productive manufacturing enterprises.

While manufacturers, generally speaking, have been ready enough to admit that the emission from their chimneys of large quantities of black smoke was the source of a nuisance in thickly settled localities, nevertheless they have been disposed to further say that the smoke nuisance was like the fouling of streams by sewage, an incident of modern civilization which could not well be avoided, and hence, in view of the somewhat rash claim that all smoke emission from soft coal could be prevented, they have been disposed to do nothing, the more especially since the best that could be done would not absolutely prevent some smoke emissson from soft coal.

Undoubtedly this deadlock between the general public and the consumers of soft coal has resulted largely from a lack of appreciation of all the elements of the problem on both sides; and as preliminary to clearing away the difference, it is desirable that every person be made to understand the natural limitations imposed by conditions which are beyond the control of man. Under this head we may call attention to the considerable variation in meteorological conditions from day to day, and the marked

influence which they exert upon the completeness of combustion. For instance, we have variations in :—

1. The humidity of the air, or the amount of moisture contained in a unit volume of the same.

2. The barometer, or what is the same thing, variations in density, with a consequent change in the quantity of oxygen per unit of volume.

3. The temperature, from whence results, on cold days, a greater consumption of heat to raise the large quantities of air required for complete combustion to the temperature of the fire.

4. The force and direction of the wind, which, even though other things are equal, will of itself considerably influence the completeness of combustion.

Again, the quality of the coal used, even though all from the same mine, will vary considerably in different lots.

A mere recital of the foregoing several modifying elements of combustion, which are beyond human control, is enough to show not only the impossibility of absolutely preventing *some* smoke emission, but also to show that *some* variation in completeness of combustion must inevitably take place from day to day. The real questions for consideration are, therefore :—

1. What is the actual limit of smoke prevention which may be on an average practically attained in the present state of our knowledge of the laws of combustion, without imposing unjust burdens upon the consumers of soft coal ; and,

2. Will such practical results as can be attained with the limitations imposed by the latter part of the preceding clause fairly satisfy the demands of those who are not interested, as consumers, in the use of soft coal, and who, hence, look upon smoke prevention from the point ot view of one who may be considered as injured by the commercial operations of his neighbors ?

In answer to the two questions, it is stated, (1) That it is quite practicable to prevent from 75 to 90 per cent. of the visible black smoke ; and (2) The preventing of this amount is in effect a practicable removal of the nuisance, as may be demonstrated by the following considerations :

We have already shown, on page 5, that the office of the natural steam of smoke is to convey the unconsumed carbon into the higher regions of the atmosphere, thereby so distributing and

diluting the same as to render it innocuous, and we may now inquire as to the amount of such carbon resulting from ordinary smoke producing combustion. Direct proof on this point is afforded by an experiment of J. C. Hoadley, C. E., who passed through water all the gases from a furnace fired with bituminous coal, producing a very black smoke. The amount of coal burned was 12,890 pounds, every pound of which generated 25.23 pounds of gases, hence the total weight of gases was 325,215 pounds, with their total volume amounting to 4,263,119 cubic feet. The total solid matter contained in this volume of smoke was carefully collected, dried and weighed, and found to be 42.63 pounds, or one-third of one per cent. Of this probably one-half was ash; whence it appears that the unconsumed carbon which made the visible smoke represented only about one-sixth of one per cent. of the weight of the coal consumed, or say, 21.3 pounds in 12,890 pounds.

Experiments, under favorable conditions, with Sargent's Automatic Smoke Preventing Apparatus, indicate that from 75 to 90 per cent. or more of the black soot may be consumed on an average from day to day, and this, we conclude is the practicable limit of smoke consumption or prevention in the present state of the art. Manufacturers operating soft coal furnaces should on the one hand be willing to apply an apparatus which may be expected to afford these results, while on the other hand the public at large should accept such results as the best that can be done at the present time. On the basis of 75 per cent. smoke consumption, we have in the case of a furnace using one ton of soft coal per day an escape into the air of only a little over eight-tenths of a pound of black carbon per day.

We have shown on page 5 that the steam naturally generated as a residual product of combustion, performs an important office in diffusing the solid carbonaceous matter of smoke in the upper atmosphere. In addition to the natural steam, we have present, when the steam jet system is used, that portion of the steam operating the jet which is not decomposed into its constituent elimentary gases, as further shown on page 5. We also have the result of the recombination of such decomposed steam, whatever form it may take. It appears, therefore, that the net outcome of the use of the steam jet system is (1) A reduction of the separated

carbon to a mere nothing, with (2) Such an increase of the quantity of steam present in a given volume of smoke, as to assist greatly in the additional dilution and dissemination of the small quantity of black carbon which may still remain.

Taking into account, then, the small amount of unconsumed carbon which may still escape, we conclude that a reduction of even two-thirds of the black smoke would be practical smoke prevention at the present time. As a matter of fact, all the plants thus far fitted with Mr. Sargent's appliance show a reduction of the black smoke to less than one-fifth of its former volume.

THE PROPER METHOD OF FIRING.

The average steam boiler furnace wastes a large amount of coal by reason chiefly of improper firing ; and while it is beyond the limits of a treatise of this character to give full directions covering every case, the following will, if followed, be of value to every user of soft coal.

In the first place, firing is hard work, and the tendency of the average fireman is to feed in too much coal at one time, the evident intention being to thereby increase the length of time between fresh fires. The outcome of this is, that for a short period after each application of fresh coal, what may be termed the natural smoke consuming capacity of the furnace is overtaxed, with the result that a considerable portion of the distilled hydrocarbons is unconsumed, and hence pass off as smoke. Moreover, this loss of hydro-carbon is accompanied by that form of incomplete combustion which produces carbonic oxide instead of carbonic acid, with a consequent great loss of heat as already detailed on a previous page.

The clear remedy is more frequent firing with smaller quantities of coal to each fire.

Again, even when the amount of coal added at each firing is not too great, the tendency frequently is to wait until the old fire has so far burned out as to become lower than is compatible with the conditions for perfect combustion as defined on page 4. In this case, the adding of fresh fuel results the same as before,

namely, in the distillation of heavy hydro-carbons, which pass away as smoke.

In a few words, we may say, then, that more frequent firing, with smaller quantities of fuel will lead to considerably better results than are gained by the usual method. Firing alone, however, even though carefully conducted, cannot be relied upon to prevent smoke emission, although when joined with the use of Sargent's Automatic Appliance, a practically smokeless combustion easily ensues.

As further useful hints we may say :—

1. The fire should be evenly distributed over the entire surface of the grate, and not heaped up in front, with the grate nearly uncovered at the bridge wall, as is sometimes the case. Leaving the grate uncovered at the rear end of the fire box permits the admission of cold air at a point where it can only do harm.

2. Large pieces of coal should be broken into small lumps, and in firing, distributed evenly over the entire area of the fire, or better, over the front half of the fire box, and pushed back as combustion proceeds at the rear. In this way, the rear half of the fire box is supplied only with coked fuel from which the constituents of smoke have always been fully driven off.

3. The opening of the furnace door admits too much cold air, hence, as a general rule, firing must be done quickly, keeping the furnace door open as short a time as possible.

4. Ash-pits should be frequently cleaned, and the air spaces between the grate bars kept free.

The only objection that can be urged against the foregoing brief hints is that they increase somewhat the labor of firing. A strict compliance with them will by itself decrease fuel consumption at least 5 per cent. Their rigid use in conjunction with the Automatic Smoke Appliance will decrease fuel consumption for a given amount of work to be done from 10 to 15 per cent.

The foregoing brief discussion of the principles involved in rational smoke prevention and the application thereto of the Automatic Chronometric Apparatus is put forth in the hope that it may be of essential use to the owners of steam plants throughout the country. All inquiries in regard to the apparatus will be

cheerfully answered by Mr. Sargent, who may be addressed at No. 608 Wilder Building, Rochester, N. Y. Applications for the purchase of state, county or city rights may also be made either by letter or in person to Mr. Sargent at the same place.

The time movement and the other special fittings are manufactured by the well-known firm of Sargent & Greenleaf, of which firm Mr. Sargent is the senior member.

OFFICIAL INVESTIGATION OF SARGENT'S AUTOMATIC SMOKE PREVENTER.

ROCHESTER, N. Y., May 16, 1892.

The Executive Board of the City of Rochester, by request of the Mayor, joined him in witnessing a test of the smoke preventor invented by Mr. James Sargent, and in use on the boiler at Sargent & Greenleaf's lock factory. A liberal quantity of soft coal was thrown into the furnace in the usual manner and the doors closed.

Immediately the black smoke and soot were rolling from the top of the chimney in great profusion. Mr. Sargent then put his appliance in operation, and in less than half a minute the volume of murky smoke was reduced to a thin white vapor. These changes were repeated several times by simply removing and restoring the use of the appliance, without other alteration in the furnace or fuel, and each time with the same result.

We believe this smoke consumer to be the simplest and most effective appliance of its kind ever offered to the public ; it can be attached to the front of a boiler while in full operation, without injury to the setting of the boiler, or stoppage of the works.

From results produced and re-produced in our presence, we have reason to believe that its general adoption by consumers of soft coal, would satisfactorily abate the prevailing "smoke nuisance."

RICHARD CURRAN,
Mayor.
GEO. W. ALDRIDGE,
W. W. BARNARD,
JOHN U. SCHROTH,
Executive Board.

OPINION OF DR. CHAS. E. RIDER, THE FAMOUS OCULIST AND INVENTOR, OF ROCHESTER, N. Y.

ROCHESTER, N. Y., May 27th, 1892.

Mr. James Sargent, Rochester, N. Y.:

DEAR SIR,—I have carefully examined your appliance for the prevention of smoke in burning bituminous coal and agree with the expressed opinion of other witnesses as to the success of the tests made in our presence.

It is an undisputed fact that we have only to mix the requisite quantity of air at the proper temperature with the distilled hydrocarbon gasses in order to effect perfect combustion, and that perfect combustion leaves no soot.

It is well known that one of the simplest means of effecting this mixture is a jet of steam properly directed and variable in volume. But the difficulty has been to cause this variation in volume by automatic means, too much having been left to the volition of firemen. It seems to me that your combination of the clock with the steam jet is well adapted to the requirements, the jet acting in full force while the evolution of the combustible gasses is at its height, and ceasing almost entirely when the coal has become fully coked and no more hydrocarbon gas is evolved.

Yours truly,

C. E. RIDER, M. D.

OPINION OF PROFESSOR S. A. LATTIMORE OF THE UNIVERSITY OF ROCHESTER.

ROCHESTER, N. Y., June 30, 1892.

I have recently had the opportunity of examining and personally testing the efficiency of Sargent's Automatic Smoke Preventer as applied to steam boiler furnaces in three large manufactories of this city.

The use of bituminous coal in furnaces of ordinary construction inevitably results in the production of smoke in great abundance. With the increasing consumption of such fuel the

smoke nuisance in this city has within a few years become unbearable. That it must be abated in some manner speedily, admits of no doubt. The important question is as to a practicable method. Many ingenious and elaborate devices have been contrived, for the purpose of consuming the smoke after its escape from the fire chamber, or of preventing its formation. Most of them have proved in practice either inefficient or cumbersome and costly.

As is well known, smoke results from the imperfect combustion of the more volatile hydrocarbons of bituminous coal. The more highly inflammable hydrogen of these compounds combines with the oxygen of the air forming water, or rather steam, while the less inflammable carbon escapes combustion and appears as a cloud of smoke, precisely as when in a kerosene lamp an excess of oil is volatized by turning up the wick. The smoke, therefore, is so much unburned or lost fuel.

The common practice in the management of steam boiler furnaces is to add the fuel at intervals. The temperature rises as combustion proceeds. When the maximum is reached a fresh supply of fuel is suddenly cast upon the glowing fire. At this high temperature the more volatile constituents of the coal are rapidly converted into the gaseous form, leaving the less volatile portions of the coal, in the form of coke, to undergo a slower combustion without smoke. Any one by observing the top of a smoke stack can tell when fuel is being added by the sudden increase in the volume of smoke. The supply of air best adapted to the slower combustion of the coke is inadequate to the complete combustion of the volatized portions. If the supply is increased by opening the furnace doors, before the air and gases can mingle, the temperature of the latter is reduced by the former below the point of ignition, and thus combustion is arrested rather than augmented, and the unconsumed carbon mixed with air and the products of combustion, mainly carbonic acid and steam, is carried up the chimney and discharged as a cloud of smoke. In speaking of air as promoting combustion it is to be borne in mind that in reality it is only one portion of the air—the oxygen, constituting but 20 per cent. of its bulk—which is available, the other 80 per cent. of inactive nitrogen only serving to dilute the oxygen and weaken its activity. Moreover the

nitrogen vastly increases the volume of gases issuing from the furnace, thus largely contributing to defeat any project for burning the smoke after it has once escaped from the fire chamber.

The real and serious defect of all ordinary methods of steam boiler furnace construction does not consist in the difficulty of introducing a sufficient quantity of air, but in the impossibility of bringing it into immediate contact with the gaseous products of combustion at the instant of their formation, when at the maximum temperature, and thus in the most favorable condition for absolutely complete combustion. It is precisely this radical defect which Sargent's Automatic Smoke Preventer overcomes with complete success, and in a remarkably simple and philosophical manner. The secret of the success of this invention consists in projecting directly into the mass of gaseous hydrocarbons, at the moment of their formation, and at their highest temperature, a sufficient quantity of air to completely convert them into carbonic acid and steam, rendering it impossible for any unburned carbon to escape as smoke. The admission of air *in bulk*, as by opening the furnace door, as is well known, does not accomplish this result, therefore the inventor projects jets of air with high velocity into the mass of combustible vapor, thereby producing an intimate mixture the same as in the case of the common "blow-pipe." In fact this appliance is constructed precisely on the same principle. Every one knows how greatly the heat of a gas flame is increased by projecting into it a small stream of air with sufficient velocity.

In this invention the place of bellows, air-pump or other device to drive in air under pressure, which would be costly and troublesome to manage and keep in repair, is supplied in the simplest way conceivable by a jet of steam drawn from the boiler. This jet is subdivided to any desired extent by causing it to issue in the upper and anterior part of the fire chamber from a nozzle pierced with radiating holes from which the finely divided threads of steam are shot into the mass of burning fuel. Each thread of steam drags along with it, on the principle of the Giffard injector, a quantity of air, which is the efficient agent in producing complete combustion. While the agency is apparently a steam-jet, it is really an air-jet produced by steam power.

The air blast is necessary, however, only for a limited period after the addition of a fresh charge of fuel. When the volatile hydrocarbons are all distilled of and burned and the coal reduced to coke, the further continuance of the blast would be useless and a waste of steam. It is, therefore, made intermittent in its action to correspond to the intermittent firing. This end is accomplished by means of a simple clockwork movement, capable of adjustment so as to regulate the blast to longer or shorter duration, according to the quantity of fuel added. The movement may be easily adjusted at pleasure and is under complete control. When the blast ceases, the combustion of the fuel, now reduced to the condition of coke, goes on with the usual air-draft until the next addition of fuel. Then the act of opening the furnace door sets in operation the blast at the instant it is needed without the slightest attention or thought on the part of the fireman.

The chief points of value in Sargent's automatic smoke preventer, in my judgment, are the following :—

1. It is extremely simple in construction, therefore inexpensive and little liable to get out of order.

2. Its application to any furnace requires no alteration in the construction of boiler or brick work.

3. It requires no change in firing or general management of boiler or furnace.

4. The steam blast is easily adjustable, both as to its force and duration, as circumstances may require.

5. As it suffers no part of the coal to remain unburned, it secures the highest economy of fuel.

6. It is automatic, requiring no care or attention on the part of the fireman, save the ordinary attention which the other appliances of the boiler may receive.

7. It is particularly to be observed that this invention does not aim at smoke consumption, but at absolute smoke prevention.

Therefore, it seems to me that Sargent's Automatic Smoke Preventer meets every requirement of a simple and inexpensive method of obviating the production of smoke from bituminous coal.

S. A. Lattimore.
Professor of Chemistry,
University of Rochester.

OPINION OF A NUMBER OF CITIZENS OF ROCHESTER, ETC.--WHO HAVE WITNESSED THE OPERATION OF THE SMOKE PREVENTING APPLIANCE.

We, the undersigned, citizens of Rochester, N. Y., have examined with care Mr. James Sargent's new device for preventing smoke, and have witnessed with much interest a test of the same in operation on the furnaces of Messrs. Sargent & Greenleaf in the boiler room of their lock factory, and we regard it as the most complete and efficient device of its kind yet presented to the public.

The entire device appears to be simple and easy of adjustment to any boiler front, and is a much needed appliance in which success will be hailed by all as a public benefaction.

C. R. Parsons, ex-Mayor and Senator.

Wm. Carroll, Ex-Mayor, Rochester.

L. Sunderlin, Jeweler.

James R. Chamberlin, Rubber Goods.

J. A. Warner, Mgr. Syracuse Branch,

Park Bros. & Co., Pittsburg, Pa.

R. F. Osgood, Patent Attorney.

P. F. Gildea, M. D., New York.

Father Stewart : In common with suffering humanity, I thank Mr. Sargent for his boon.

Max Brickner, president Chamber of Commerce.

George Moss, secretary Chamber of Commerce.

Daniel W. Powers.

James G. Cutler, architect.

Henry C. Brewster, banker.

John G. Allen, principal Rochester Free Academy.

Albert L. Arey, instructor Natural Sciences, Rochester Free Academy.

Thos. F. Carroll, chief Engineer Rochester Railway Co.'s Power House.

Samuel Sloan.

H. B. Hathaway, brewer and maltster.

S. Remington, wholesale grocer.

J. Emory Jones, machinist.

Barr & Creelman, plumbers.
F. S. Minges.
Henry Baldwin, superintendent Rochester Trust & Safe Deposit Co.
Dr. J. C. Urquhart.
J. C. R. Hollister, engineer The Graves Elevator Co.
J. J. A. Burke, M. D., Board of Health.
A. B. Norcross, machinist.
R. H. Salmons. manufacturer.
E. Van Camp, Cleveland Varnish Co.
F. B. Webster, agent.
James S. Davis, Chicago.
Fred Hetzel, steamfitter.
S. V. Pryor, shoe manufacturer.
C. W. Trotter, furnaces, etc.
Clarence J. Browning, lawyer.
Emory A. Almy, New Osburn house.
Charles Wallis, pattern maker.
S. Stein, casket manufacturer.
Rowland Milliman, undertaker.
James G. Ardry, books.
Anson C. Allen, clothier.
E. B. Sintzenich, boiler manufacturer.
C. B. Miller, engineer, Wilder building.
Charles A. Phillips, of Phillips & Co., coal dealer.
B. F. Cromwell, engineer, Exchange Place building.
John Van Voorhis, attorney at law.
Theodore G. Thomas, Rochester Engineering Company.
Amos Walder, manager Genesee Foundry Company.
W. J. Dunn, W. S. Kimball & Co.
H. F. Powell, superintendent R. V. Paving Company.
Daniel B. Murphy, Burke, Fitz Simmons, Hone & Co.
F. A. Shale, furniture.
O. B. Jones, superintendent.
W. R. Gray, cutter.
Otis Clapp, N. W. Life Insurance.
D. J. Chaffee, M. D.
John Gorton, real estate.
H. J. Sickles, Jinkins Bros., New York city.

David Hoyt, secretary Monroe County Savings Bank.
E. Frank Brewster, wholesale grocer.
W. W. Starr, boiler inspector.
L. C. Tower, real estate.
A. L. Jenks, Avon.
W. W. Rundel, art dealer.
George W. Eldridge, engineer at N. H. Galusha's.
Arthur F. Mundy, representing Schaffer & Budenburg, New York.
Moses Marcille, janitor Union Bank.
P. S. Townsend, superintendent Bradstreet Co.
John W. Force, treasurer hoop manufactory.
H. E. Ball, clerk Estate of Hiram Sibley.
L. J. Midler.
Irwin T. Davis.
Henry H. Turner, manager Gundlach Optical Co.
R. T. Tuttle, Perry, N. Y.
M. H. Olin, Perry, N. Y.
A. J. Moran, Inspector.
John Weiss, gentleman.
George B. Page, harness manufacturer.
Peter M. Knipper, engineer S. F. Hess & Co.
Wm. H. Jones, contractor.
W. H. Williams, contractor for boiler settings.
Frank Caum, engineer Rochester Railway Co.'s Power House.
C. W. Hausen, erecting engineer Ball Engine Co.
L. C. Smith.
H. L. Perrine, hydraulic engineer.
S. W. Puffer, grain dealer.

Sargent's Automatic Smoke Preventer.